Armed Forces College of Medicine

AFCM

Hydrocephalus & Increased Intracranial Pressure

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INTENDED LEARNING OBJECTIVES (ILO)

By the end of this lecture the student will be able to:

1. Define hydrocephalus.
2. Describe clinical picture of hydrocephalus.
3. Know different types of hydrocephalus.
4. List different modalities for diagnosis of hydrocephalus.
5. Know treatment of hydrocephalus.

What is Hydrocephalus?

The term hydrocephalus is derived from the Greek words “hydro” meaning water and “cephalus” meaning head.

As the name implies, it is a condition in which the primary characteristic is excessive accumulation of fluid in the brain.

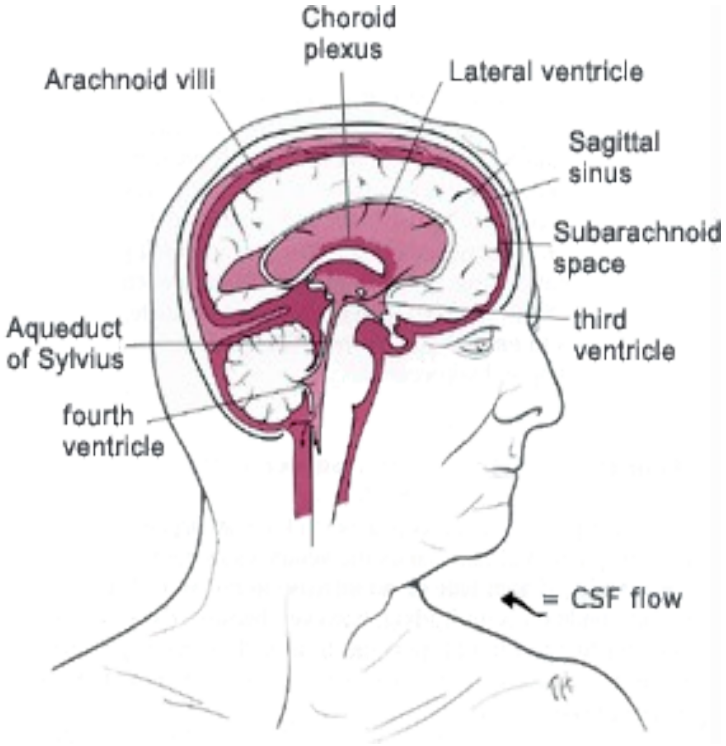
The excessive accumulation of cerebrospinal fluid (CSF) results in an abnormal dilatation of the spaces in the brain called ventricles.

This dilatation causes potentially harmful pressure on the

What is Hydrocephalus?

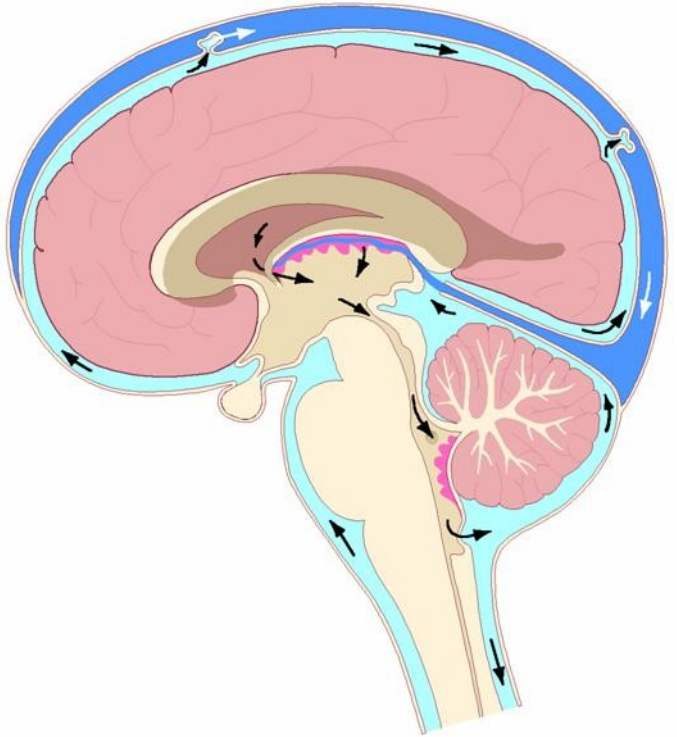
Also can be defined:

diverse group of conditions which result from impaired circulation and resorption CSF.



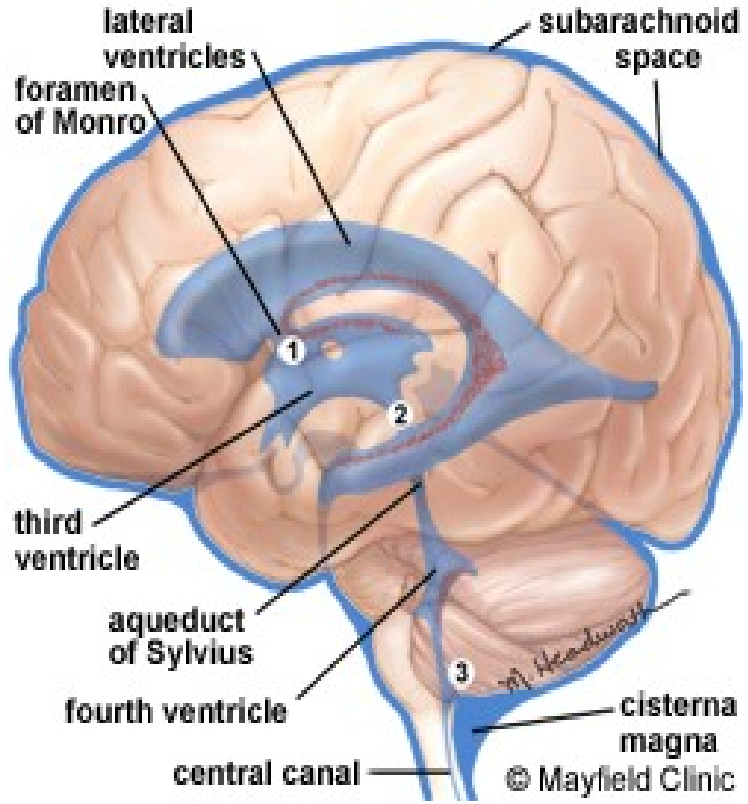
CSF Formation and Pathway

- CSF is formed by the choroid plexus .
- Normal CSF production: **20 ml/h.**
- Flows from lateral ventricles through foramina of Monro into third ventricle.
- Enters fourth ventricle through aqueduct of Sylvius.
- Enters subarachnoid space.
- Resorbed by arachnoid villi at top of brain.



CSF homeostasis

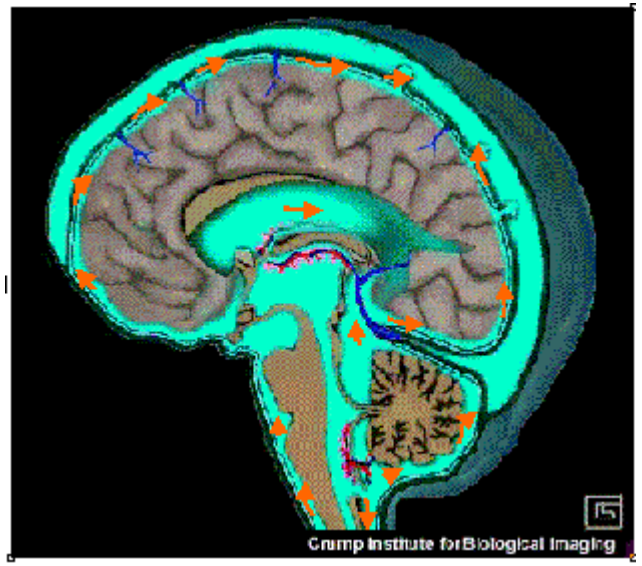
- Production: floor of the lateral ventricle and third ventricle, by choroid plexus.
- Circulation: L.V. -> III.V. -> IV.V. -> exits ventricular system into various basal cisterns and then to subarachnoid space.
- Drains back to blood via arachnoid granulation to superior sagittal sinus, or via spinal nerve roots, or via olfactory tracts.



CSF functions

CSF performs the following functions:

- Balances the amount of blood in the head.
- Bathes and protects the brain and spinal cord.
- Carries nutrients between the brain and spinal cord while removing waste.



Mechanism of hydrocephalus formation

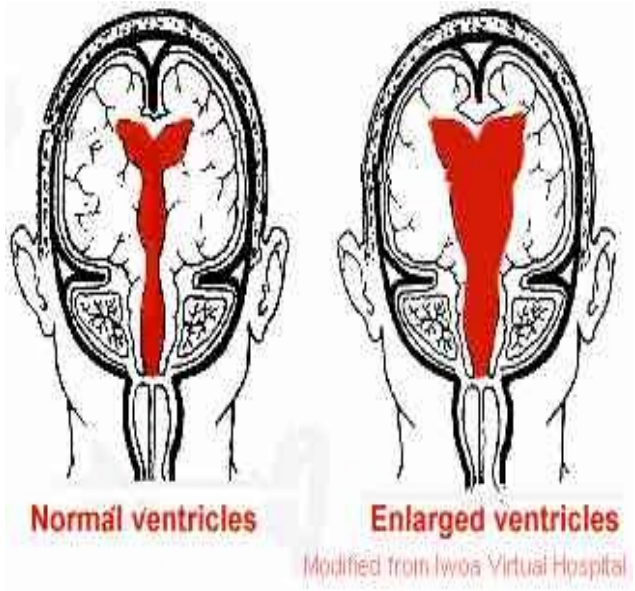
CSF

- **Obstruction of CSF pathway**
- **functional disturbance of CSF absorption**
- **Excessive production of CSF**

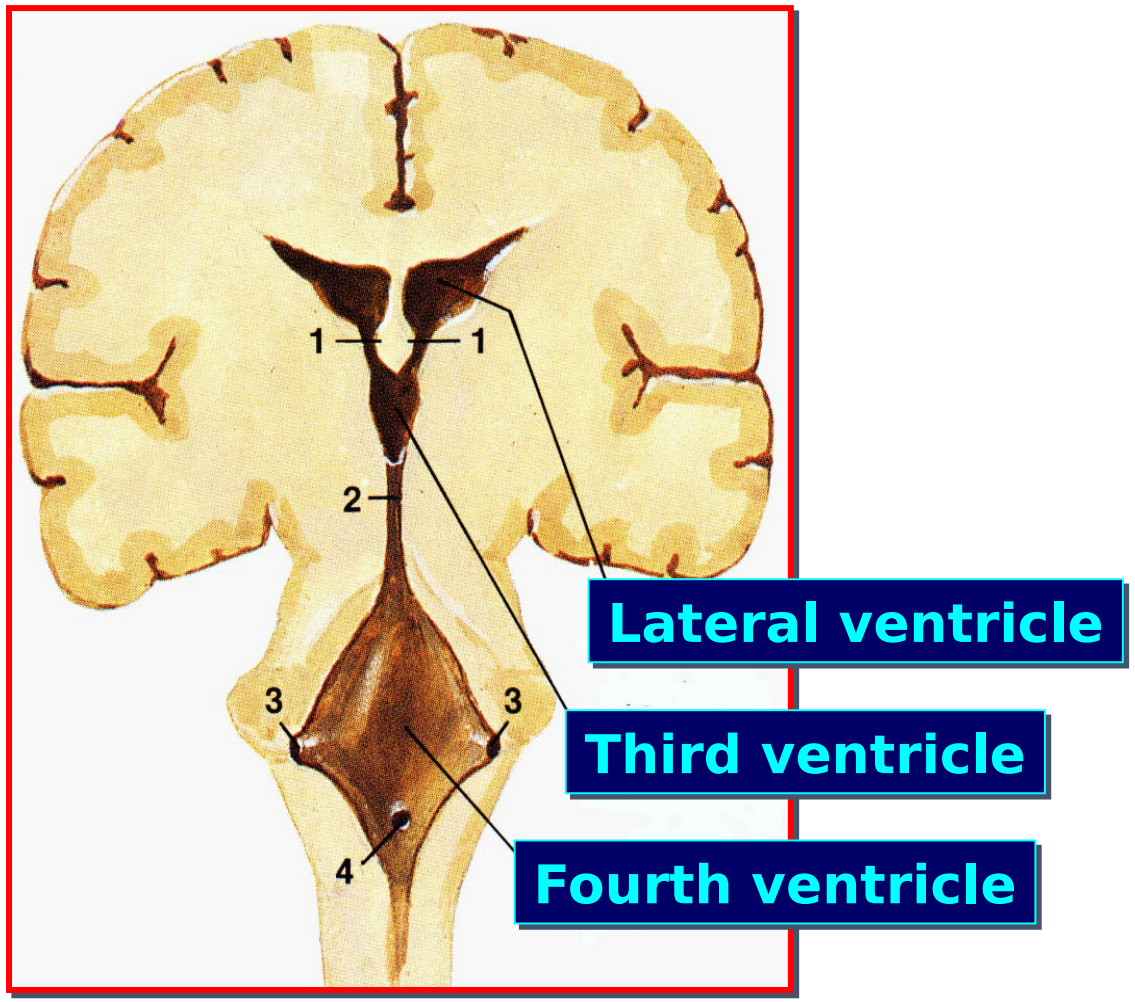
Excessive accumulation

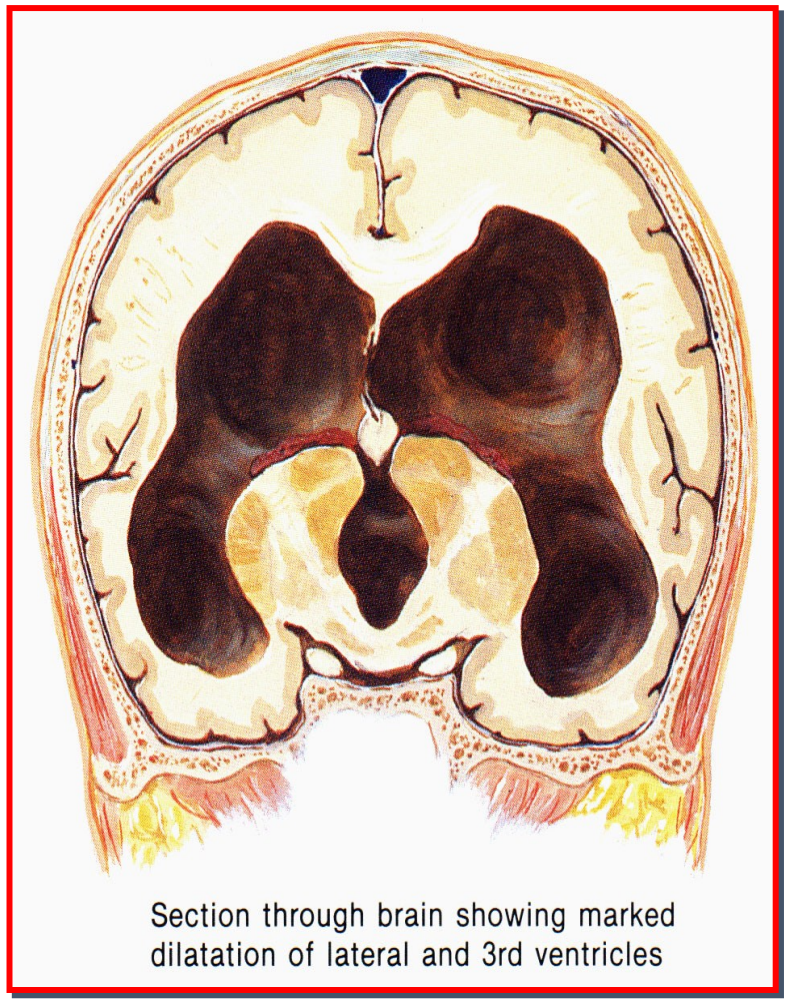
Cerebral ventricles or subarachnoid space enlargement

Head enlargement
Increasing ICP
Cerebral dysfunction



Pathologic specimen of brain





Section through brain showing marked dilatation of lateral and 3rd ventricles

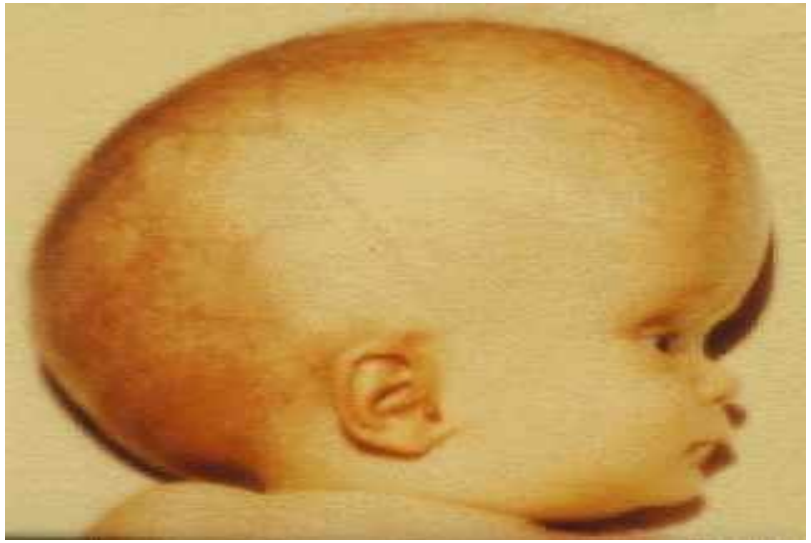
Types of hydrocephalus

According to different standards:

- Non communicating (obstructive) hydrocephalus and communicating hydrocephalus.
- Congenital hydrocephalus(developed before birth) and acquired hydrocephalus(developed during or after birth).
- Normal pressure hydrocephalus (NPH) and increasing pressure hydrocephalus.
- Acute hydrocephalus and chronic

Types of hydrocephalus

- **Communicating hydrocephalus** ⇒ the obstruction occurs in the subarachnoid space.
- **Noncommunicating hydrocephalus** ⇒ the obstruction is located within the ventricles.



Types of hydrocephalus

- Obstructive hydrocephalus
  - Congenital malformations
  - After inflammation or hemorrhage
  - Mass lesions
- Communicating hydrocephalus
  - Overproduction of CSF
  - Defective absorption of CSF
  - Venous drainage insufficienc

Causes of hydrocephalus

- **Acquired causes in infants and children:**
  - Mass lesions account for 20% of all cases of hydrocephalus in children.
  - Intraventricular hemorrhage.
  - Infections: Meningitis (especially bacterial) and cysticercosis.
  - Increased venous sinus pressure: related to achondroplasia, some craniostenoses or venous thrombosis.
  - Iatrogenic: Hypervitaminosis A, by increasing secretion of CSF or by increasing permeability of the blood-brain barrier
  - Idiopathic

Causes of hydrocephalus

Causes of hydrocephalus in adults

- **Subarachnoid hemorrhage** (SAH) causes one third of these cases by blocking the arachnoid villi.
- **Idiopathic hydrocephalus** represents one third of cases of adult hydrocephalus.
- **Head injury**, through the same mechanism as SAH, can result in hydrocephalus.
- **Tumors** can cause blockage anywhere along the CSF pathways.
- **Posterior fossa surgery**
- **Congenital aqueductal stenosis** causes hydrocephalus but may not be symptomatic until adulthood.
- **Meningitis,** especially bacterial, may cause hydrocephalus in adults.
- All causes of hydrocephalus described in infants and children

Causes of hydrocephalus

- Causes of NPH
  - SAH.
  - Head trauma.
  - Meningitis.
  - Tumors.
  - Posterior fossa surgery.
  - Idiopathic: probably related to a deficiency of arachnoid granulations.

Clinical features

- **Clinical features of hydrocephalus are influenced by the following**:
  - Patient's age.
  - Cause.
  - Location of obstruction.
  - Duration.
  - Rapidity of onset.

Clinical features

- Symptoms in infants
  - Poor feeding
  - Irritability
  - Reduced activity
  - Vomiting

Clinical features

Symptoms in children

- **Slowing of mental capacity.**
- **Headaches:** (initially in the morning) that are more significant than in infants because of skull rigidity.
- **Neck pain:** suggesting tonsillar herniation.
- **Vomiting:** more significant in the morning.
- **Blurred vision:** Consequence of papilledema and later of optic atrophy.
- **Double vision:** Related to unilateral or bilateral sixth nerve palsy.
- **Stunted growth and sexual maturation** from third ventricle dilatation.
- **Difficulty in walking secondary to spasticity.**
- **Drowsiness.**

Clinical features

Symptoms in adults

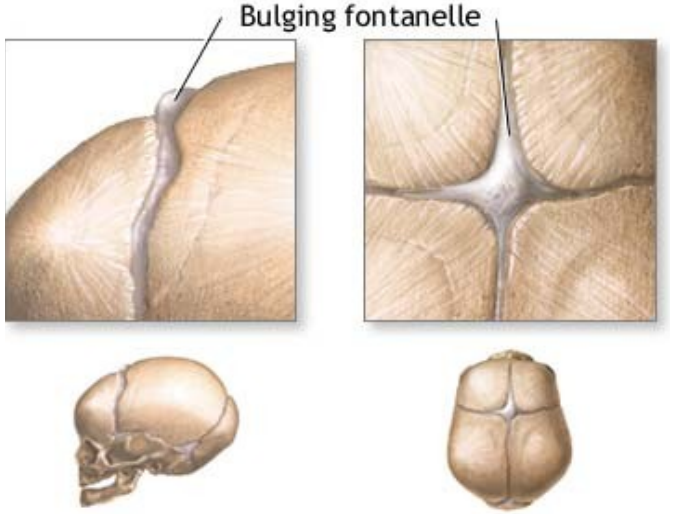
- **Cognitive deterioration**.
- **Headache**: These are more prominent in the morning. As the condition progresses, headaches become severe and continuous.
- **Neck pain**: If present, indicate herniation of cerebellar tonsil .
- **Nausea.**
- **Vomiting**: Sometimes explosive, more significant in the morning.
- **Blurred vision**.
- **Double vision** from sixth nerve palsy.
- **Difficulty in walking.**
- **Drowsiness.**
- **Incontinence:** This indicates significant destruction of

Clinical features

- Symptoms of NPH
  - **Gait disturbance** is usually the first symptom and may precede other symptoms by months or years.
  - **Dementia** presents as an impairment of recent memory or as a "slowing of thinking." The degree can vary from patient to patient.
  - **Urinary incontinence** presents as a lack of or diminished awareness of the need to urinate. Some patients may have urgency.
  - Other symptoms that can occur include aggressive behavior, Parkinson-like symptoms, and seizures.

Clinical features

- Sign in infants
  - Head enlargement.
  - Disjunction of sutures.
  - Dilated scalp veins.
  - Tense fontanelle: The anterior fontanelle in infants may be excessively tense.
  - Sun set appearance.
  - Increased limb tone.



Clinical features

- Sign of children
  - Papilledema.
  - Failure of upward gaze.
  - MaCewen sign: A "cracked pot" sound is noted on percussion of the head.
  - Unsteady gait.
  - Large head.
  - Unilateral or bilateral sixth nerve palsy.

Clinical features

- Sign of adults
  - Papilledema: If raised ICP is not treated, it will lead to optic atrophy.
  - Failure of upward gaze and of accommodation indicates pressure on the tectal plate.
  - Unsteady gait is related to truncal and limb ataxia. Spasticity in legs also causes gait difficulty.
  - Large head: The head may have been large since childhood.
  - Unilateral or bilateral sixth nerve palsy is secondary to increased ICP.

Clinical features

- Sign of NPH
  - Muscle strength is usually normal. No sensory loss is noted.
  - Reflexes may be increased, and Babinski response may be found in 1 or both feet.
  - Difficulty in walking varies from mild imbalance to inability to walk or to stand. Gait is characterized by short steps, inability to raise legs, and almost continuous activity in antigravity muscles. The patient cannot perform tandem walking and sways during Romberg test with eyes open or closed.
  - Sucking and grasping reflexes appear in late stages.

Diagnosis

How to diagnose hydrocephalus:

- Cases history.
- Symptoms and signs mentioned above.
- diagnostic imaging like Skull X-rays, echoencephalogram ultrasound, CT, and MRI.
- Lumbar punctures.

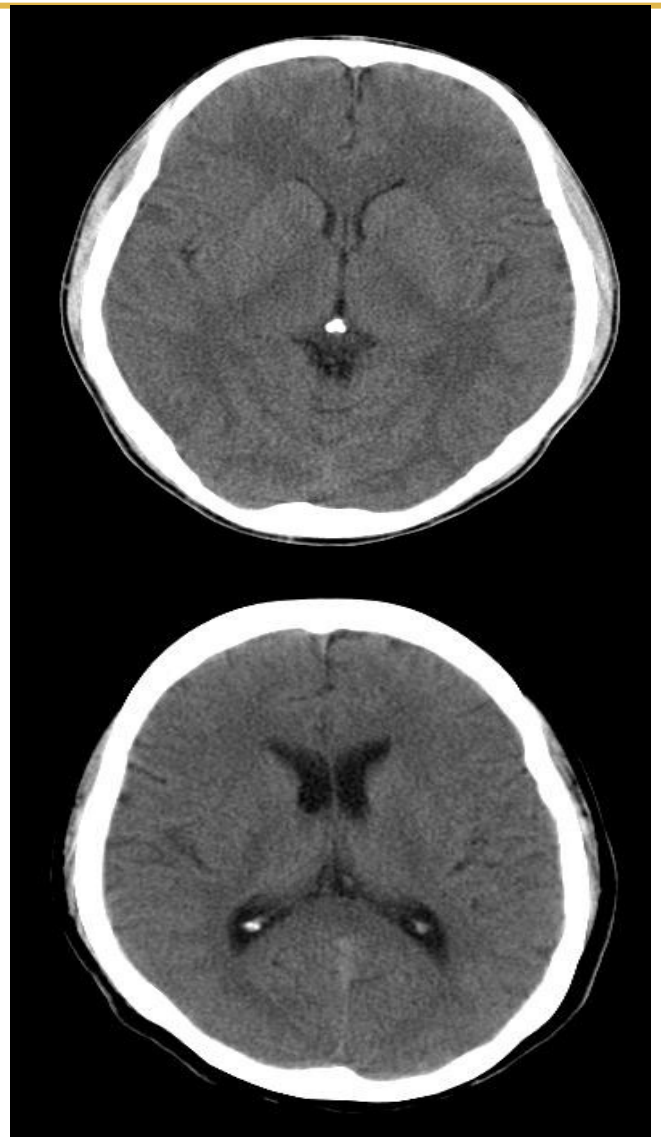
ultrasound

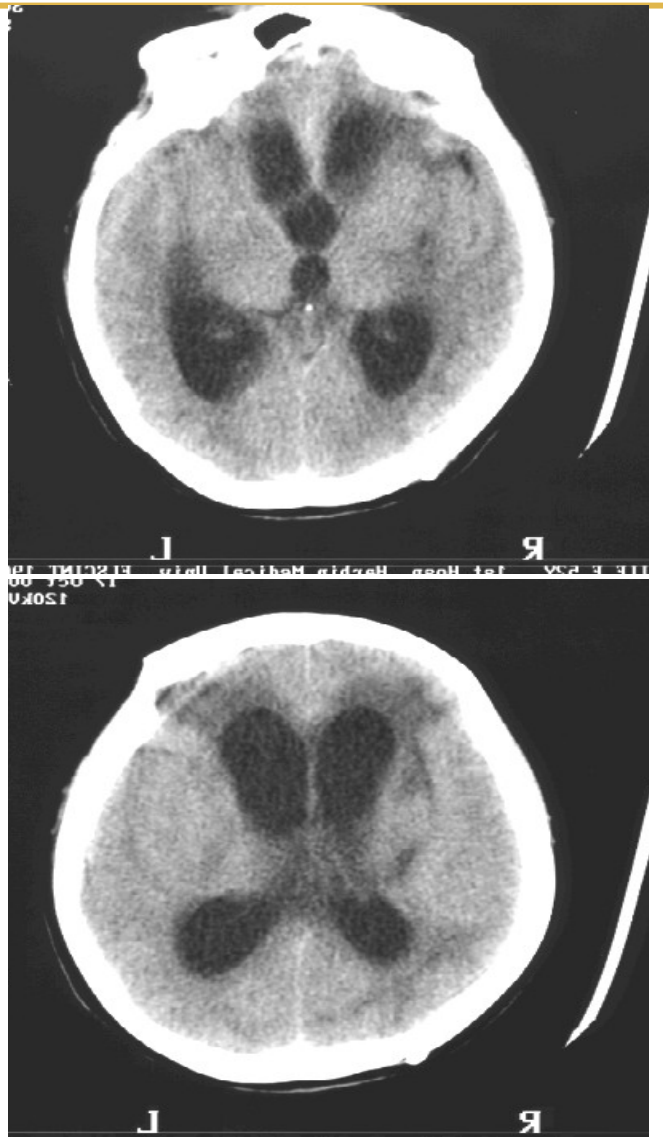
CT

MRI

Radiological Diagnosis

- CT





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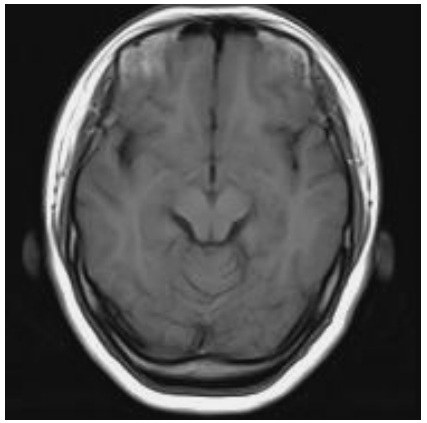
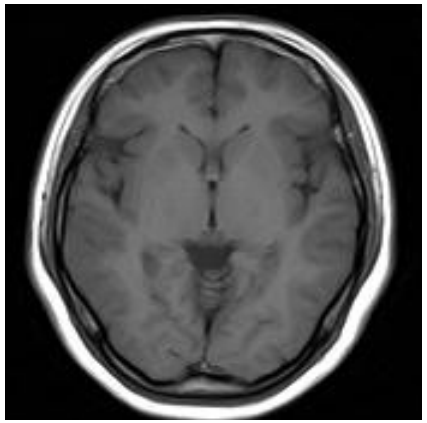
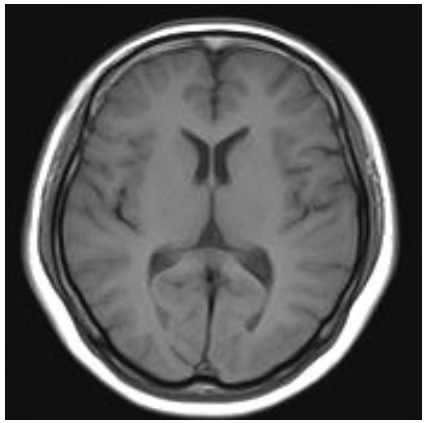
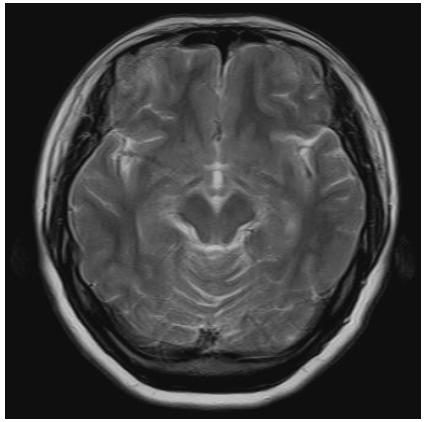
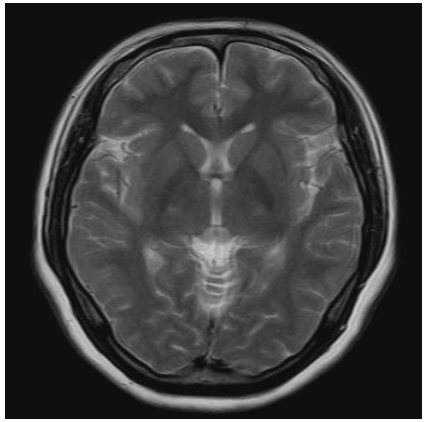
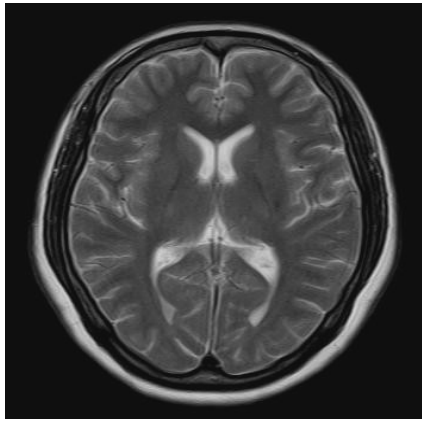
Radiological Diagnosis

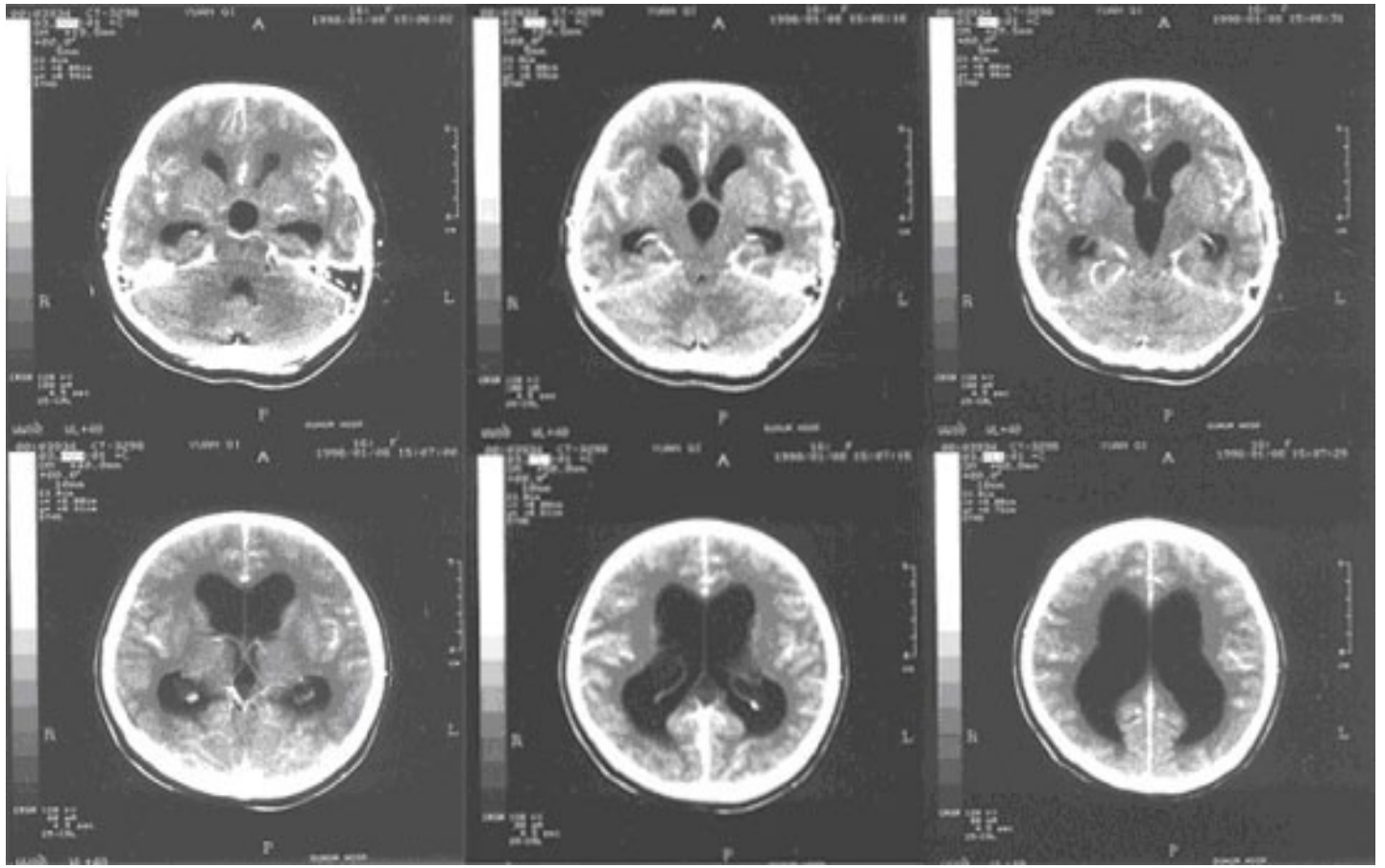
- **MRI**
  -

Normal view

Radiological Diagnosis

- **MRI**



Radiological Diagnosis

Obstructive Hydrocephalus

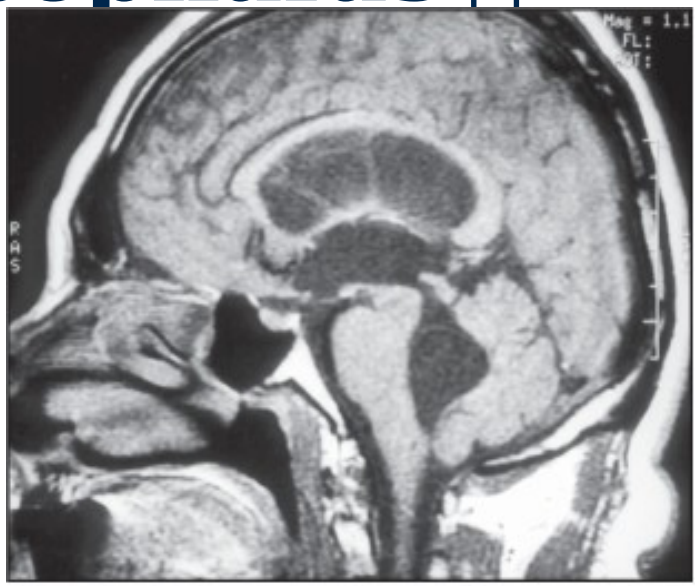
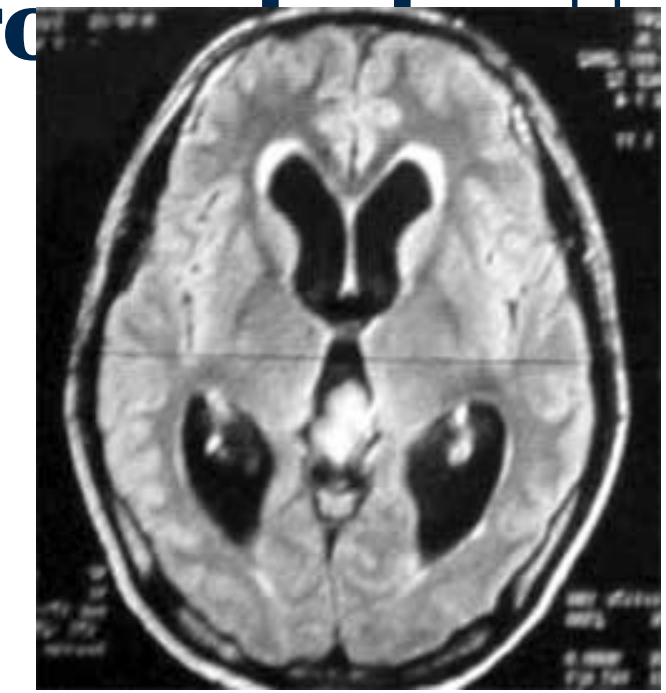


Fig 1. Preoperative sagital T1-MRI with gadolinium demonstrating dilatation of the ventricular system and a non-enhancing cyst in the fourth ventricle.

Radiological Diagnosis

- **Obstructive Hydro**



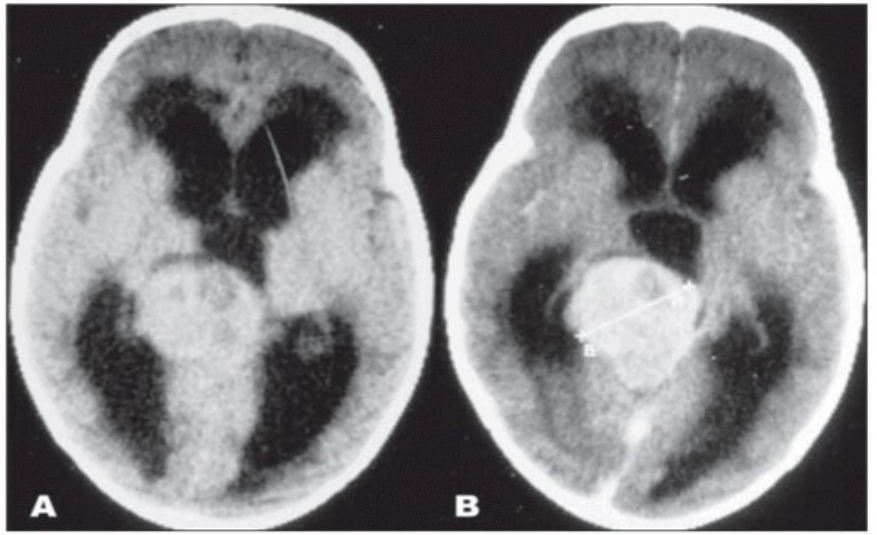
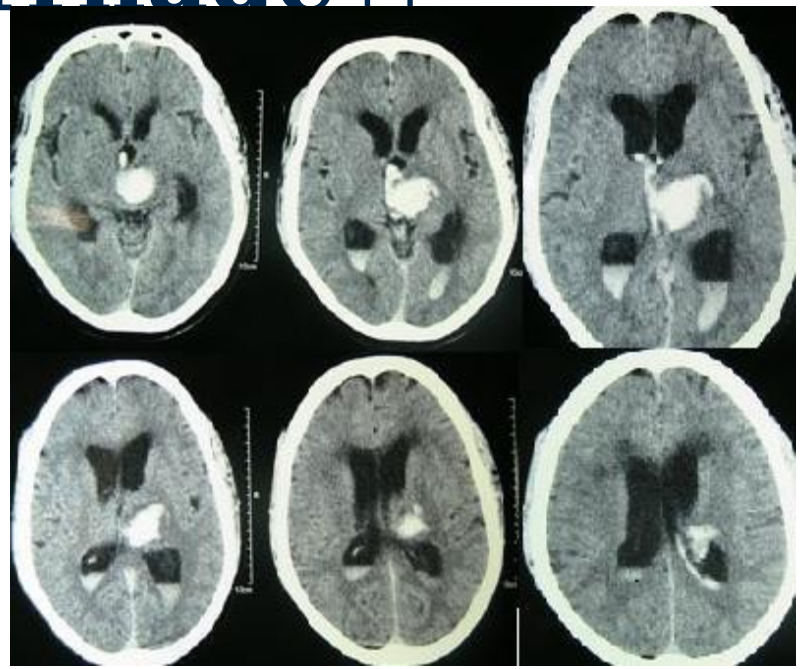
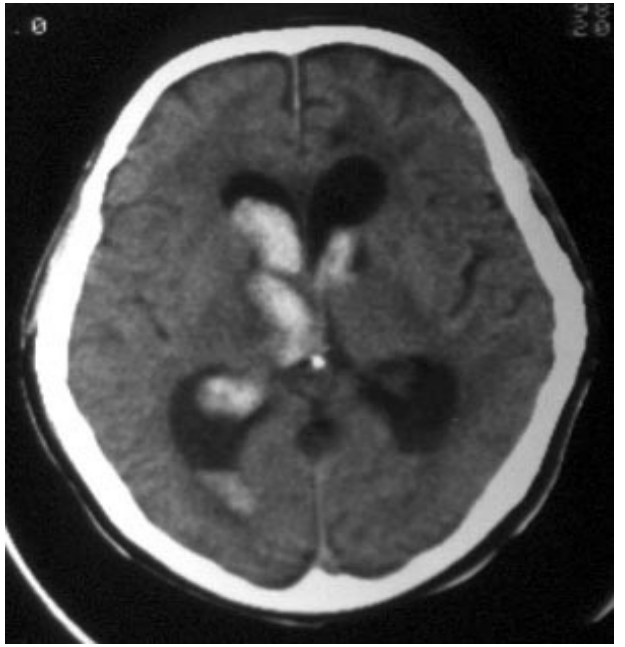


Fig 3. (A) Unenhanced CT scan reveals a round and slight high density lesion at the pineal region, compressing the posterior part of the III ventricle and the right pulvinar of the right thalamus. No peritumoral edema was seen. Ventricular dilatation and transependymal edema is demonstrated. (B) The tumor is markedly enhanced with contrast medium. Tumor size was 48 mm at the diameter indicated in the figure.

Radiological Diagnosis

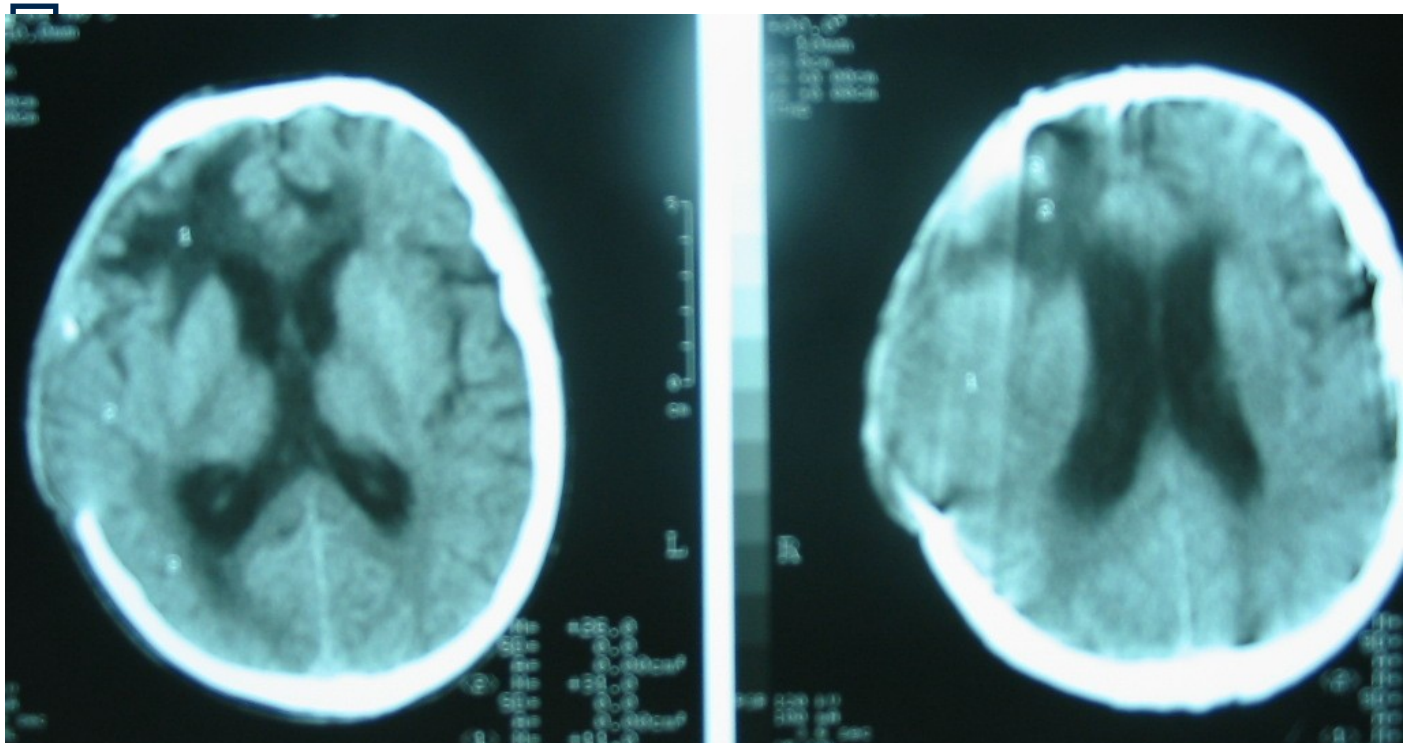
- **Hydrocephalus caused by brain hemorrhage**





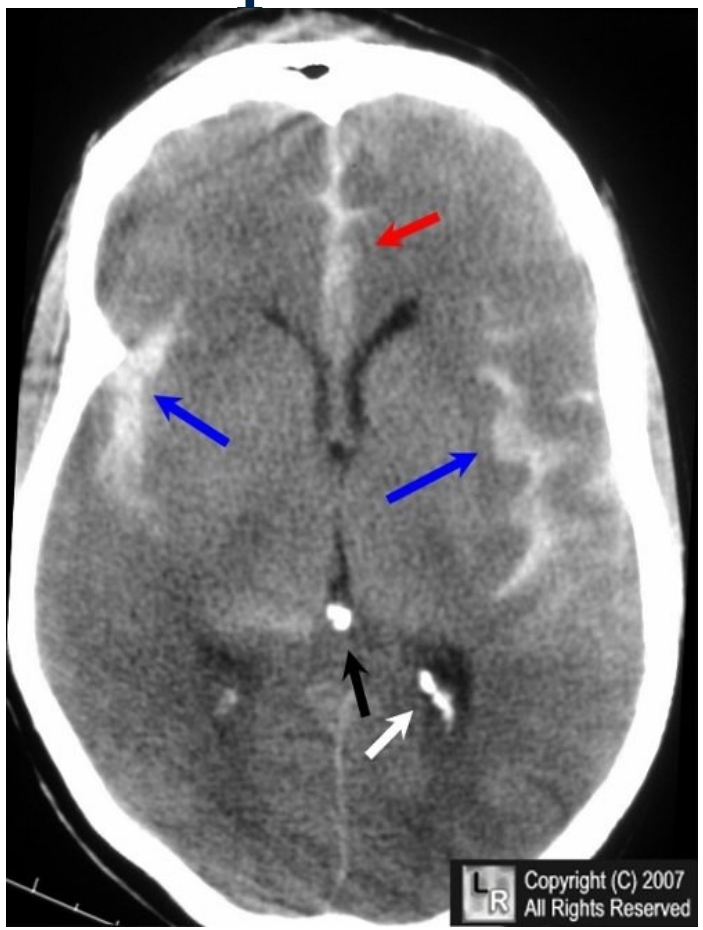
Radiological Diagnosis

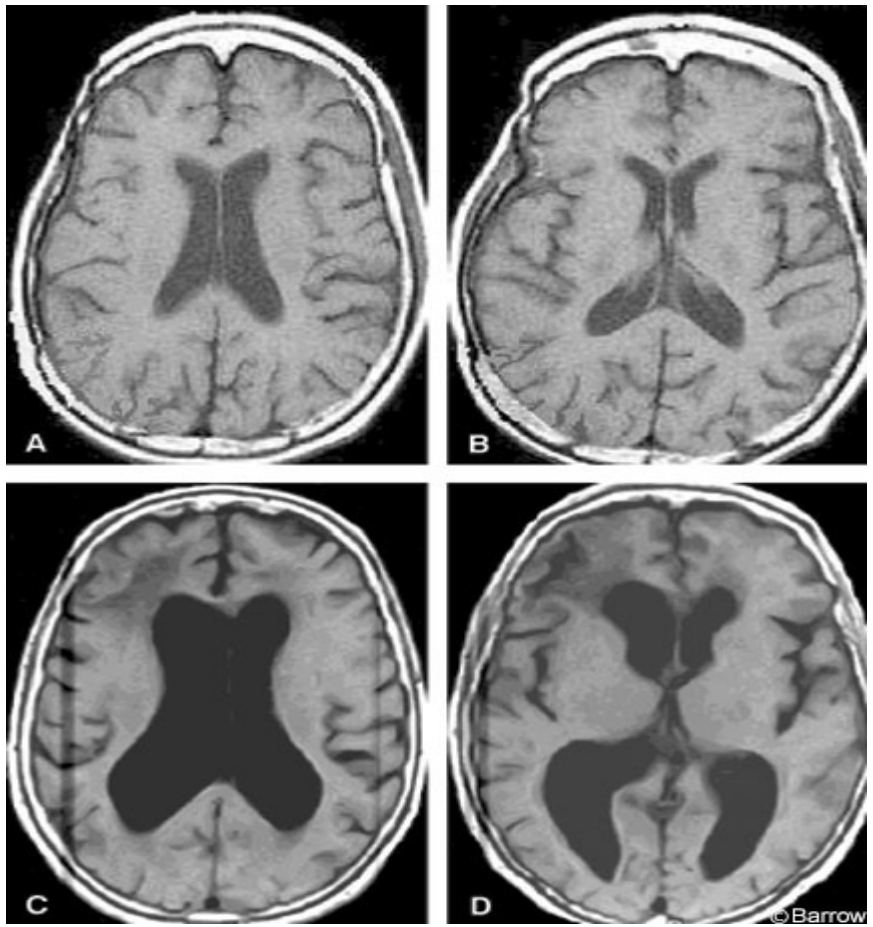
- **Hydrocephalus after head trauma**



Radiological Diagnosis

- Hydrocephalus after SAH





Treatment of hydrocephalus

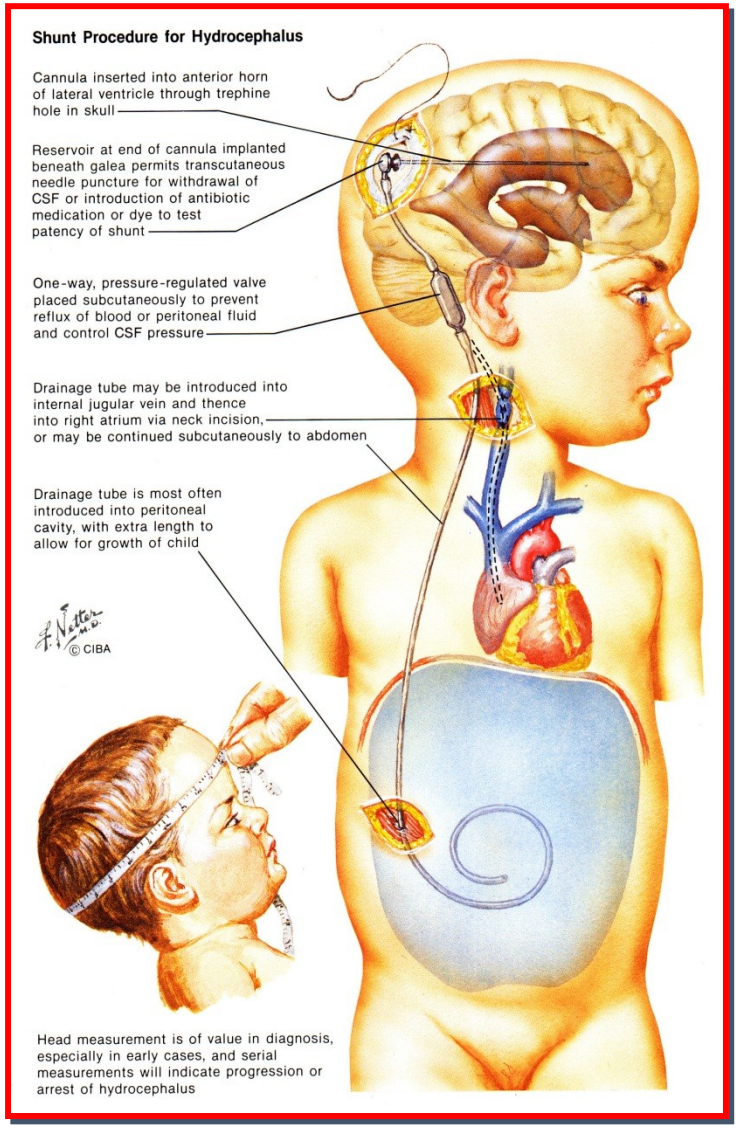
- The main goal is to minimize or prevent brain damage by improving CSF flow.
- Main therapy:
  - Medical treatment: to decrease the ICP or reduce the production of CSF with drugs.
  - Surgical interventions.

Surgical interventions

- **Treating the causes:** searching for and direct removal of the obstruction is the best strategy.
- **Shunt procedure:** the main ways are V-P shunt and V-A shunt, the most common is V-P shunt.
- **Third Ventriculostomy.**

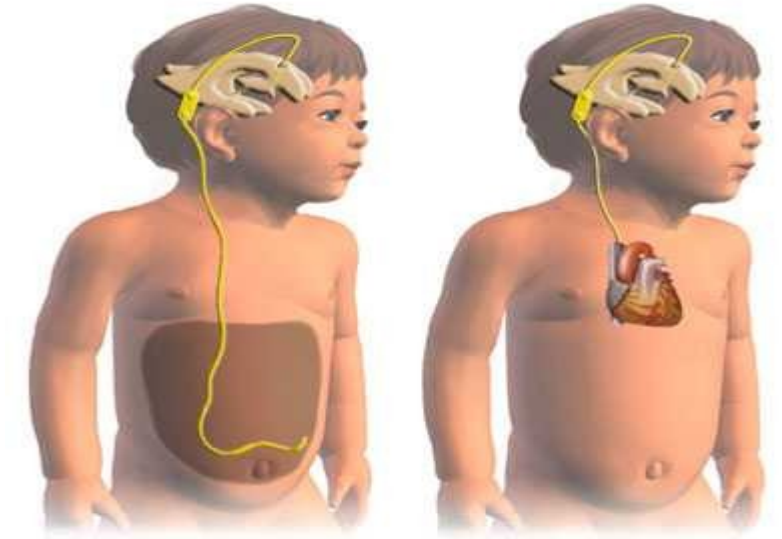
Shunt procedure

- A surgical shunt within the brain may allow CSF to bypass the obstructed area, if obstruction cannot be removed.

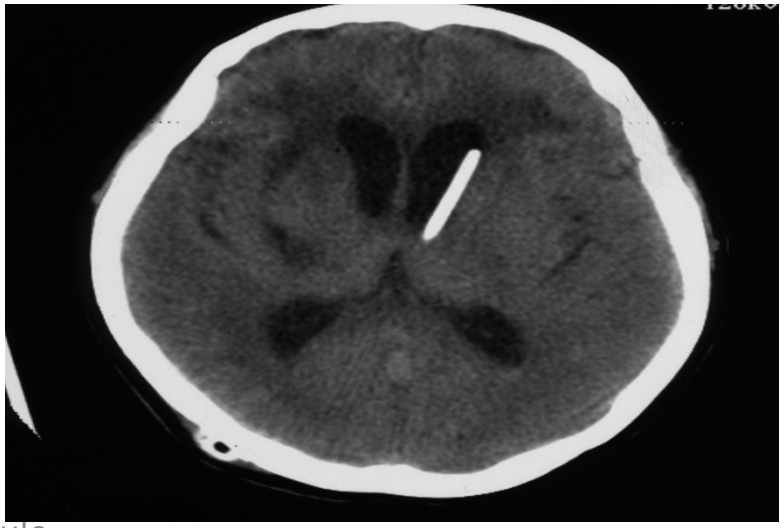


Shunt procedure

Ventriculo-Peritoneal Shunt (V-P Shunt)



Ventriculo-Atrial shunt (V-A Shunt)



Endoscopic Third Ventriculostomy

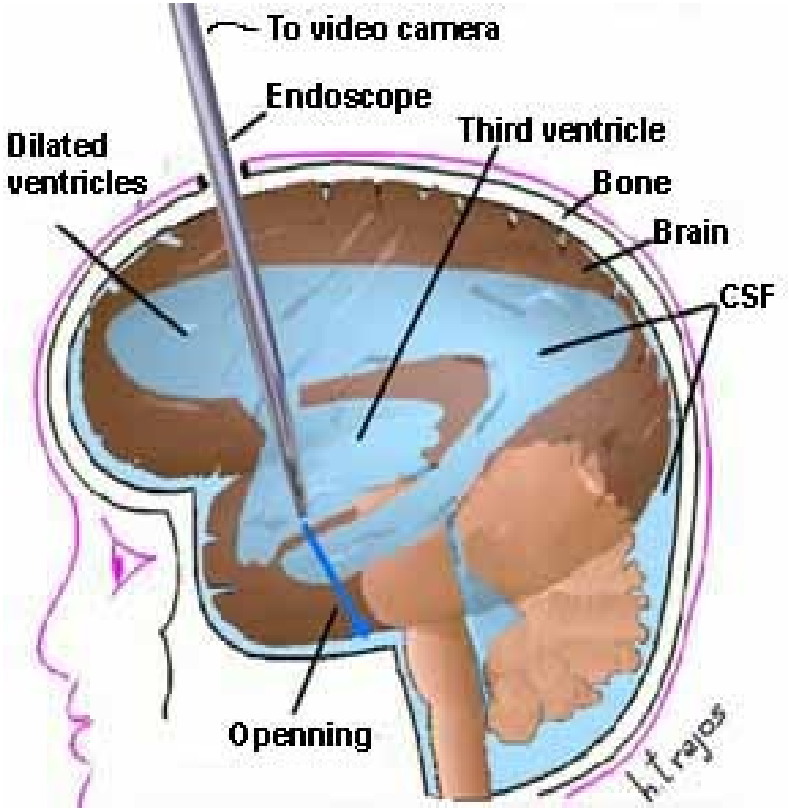
Endoscopic Third Ventriculostomy (ETV)

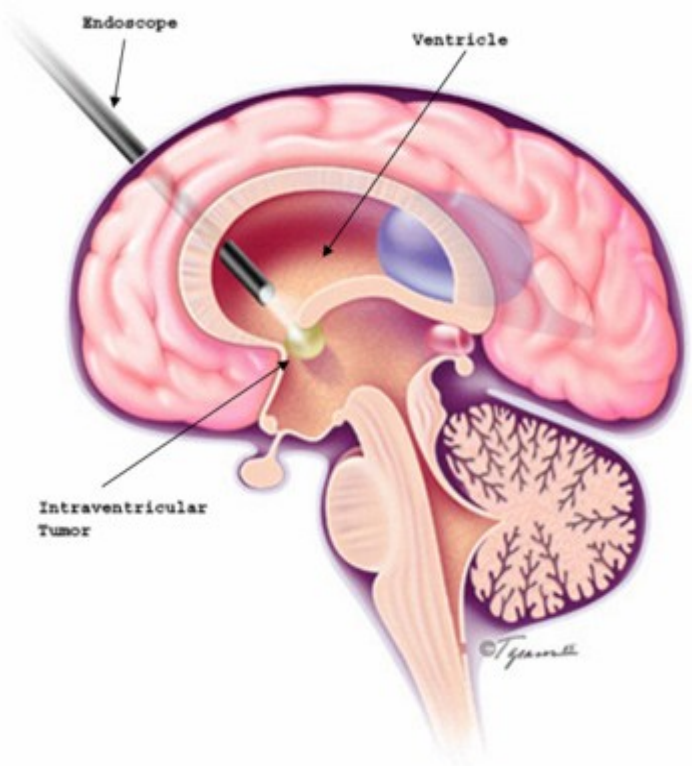
allows movement of CSF from a blocked ventricle to the subarachnoid space.

The procedure involves making tiny holes in the floor of the third ventricle allowing CSF to flow into the subarachnoid space.

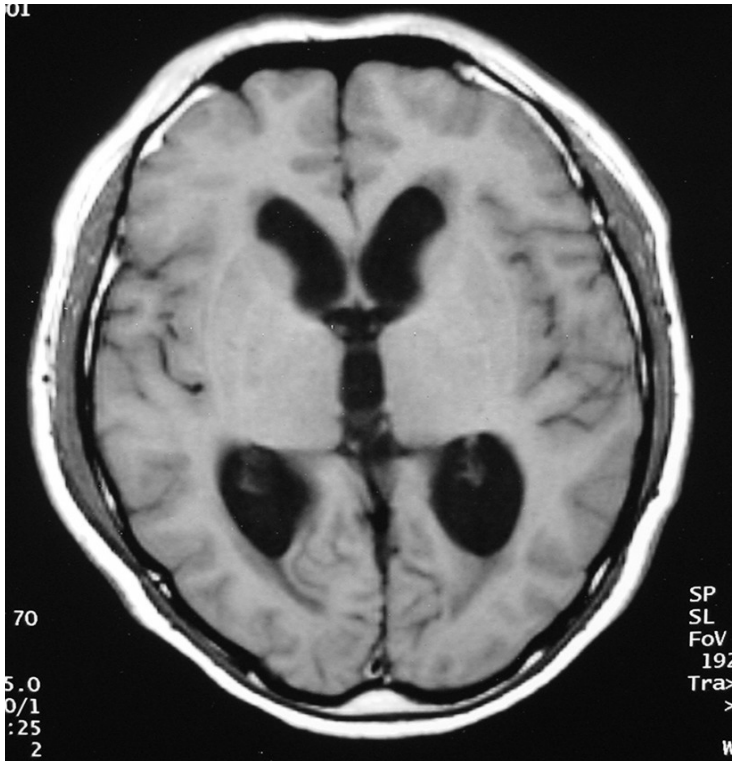
Endoscopic Third Ventriculostomy can eliminate the need for a shunt in some cases, though the procedure is not the appropriate solution in all cases.

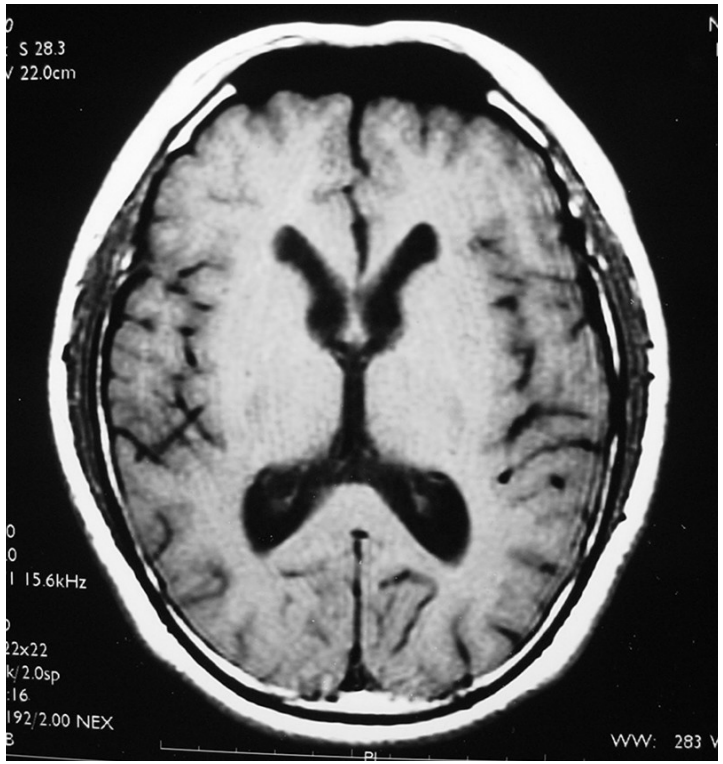
Endoscopic Third Ventriculostomy





Endoscopic Third Ventriculostomy





Pre-operation

Post-operation

Increased Intracranial Pressure

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INTENDED LEARNING OBJECTIVES (ILO)

By the end of this lecture the student will be able to:

1. Define the ICP.
2. Describe the content of skull.
3. Identify different types of brain herniation.
4. list measures to decrease ICP.
5. list manifestations of increased ICP.

Definition of Intracranial Pressure

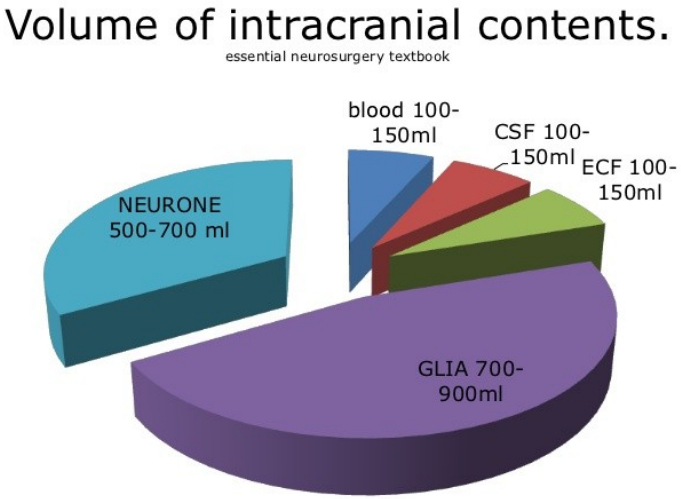
Intracranial pressure (ICP) is defined as the pressure within the craniospinal compartment, a closed system that comprises a fixed volume of neural tissue, blood, and cerebrospinal fluid (CSF).

Or it is the pressure exerted by the cranium on the brain tissue, cerebrospinal fluid (CSF) and the brain circulating blood volume.

Normal ICP is 7-15 mm Hg in normal supine position.

Content of the skull

- skull is a rigid closed structure contains
  - The brain and interstitial fluid is about 80%.
  - The CSF is About 10%.
  - The intravascular blood is abo



The Autoregulatory Mechanism of ICP

- Pressure Autoregulation

arterial vasodilatation or vasoconstriction in response to BP or ICP in order to maintain CBF.

- Metabolic Autoregulation

Arterial vasodilatation in response to chemical metabolites such as carbon dioxide, lactic acid and pyruvic acid

CO_2 is a potent vasodilator.

Cerebral Perfusion Pressure

- CPP = MAP - ICP (Normal = 70 - 100 mm Hg)
  - MAP = 1/3 Systolic + 2/3 Diastolic BP

- *CEREBRAL BLOOD FLOW (CBF)*

$$Flow = \frac{Pressure}{Resistance}$$

$$Cerebral\ Blood\ Flow = \frac{Cerebral\ Perfusion\ Pressure\ (systemic\ pressure - intracranial\ pressure)}{Cerebral\ Vascular\ Resistance}$$

The Monro Kellie Doctrine

the cranial cavity is a rigid sphere filled to capacity with non-compressible contents and that an increase in the volume of one of the constituents will lead to a ***rise in intracranial pressure***.

Failure of Compensatory Mechanism

- *WHEN COMPENSATORY MECHANISMS FAIL; Pathology OCCURS:*
- *Brain Oedema*
- *Brain Herniation*
- Ischemia if CPP (< 30-40 mm Hg)

- N.B: After head injury cerebral blood flow depends on SYSTOLIC BP (Stress)

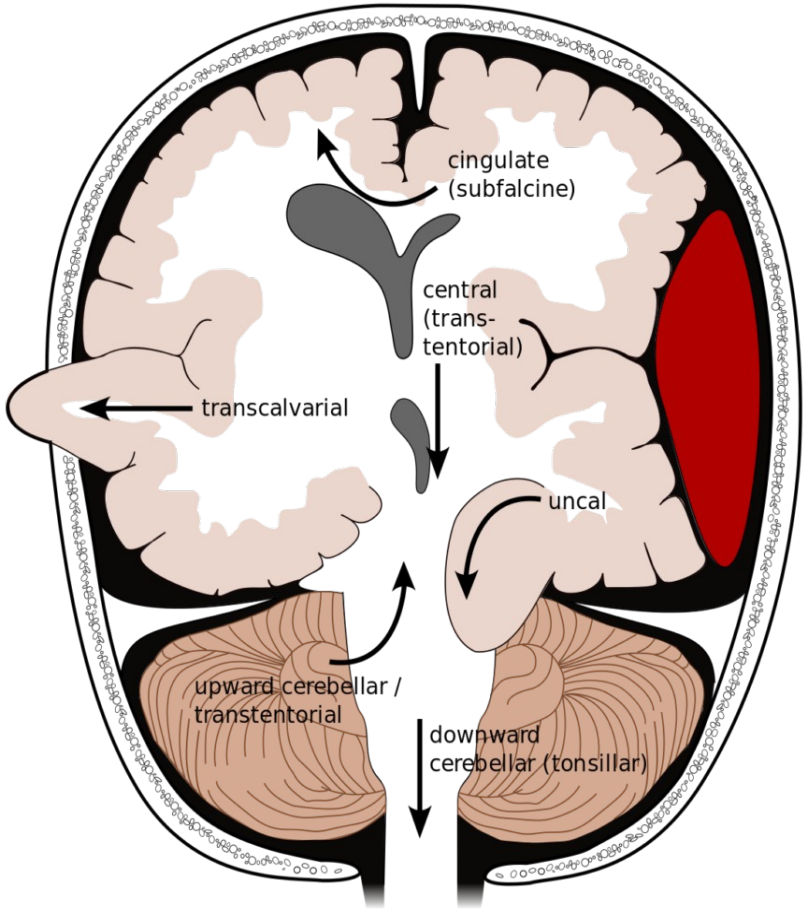
- *N.B: The ICP finally rises to the level of arterial pressure which it self begins to increase, accompanied by bradycardia or other disturbances of heart rhythm (Cushing response).*

Causes of increased Intracranial Pressure

- Mass effect: such as brain tumours, abscess, hematomas (epidural, subdural or intracerebral) and infarction with oedema.
- Cerebral oedema: post traumatic oedema, post infarction or oedema surrounding brain tumours.
- Benign intracranial hypertension: pseudotumor cerebri.
- Hydrocephalus.
- Vasodilation due to hypercapnia: high altitude or sleep.

Types of Brain Herniation

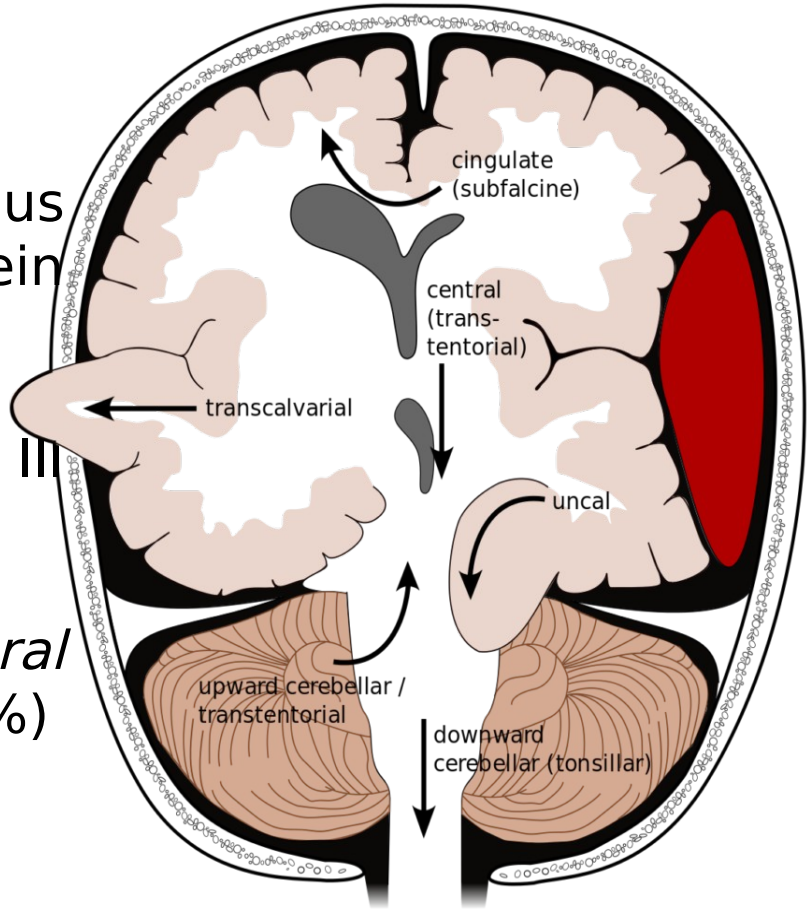
- **Subfalcine herniation:**
  - cingulate gyrus --> under free edge of flax --> ipsilateral foramen of Monro trapped --> large lateral ventricle ipsilateral, small ventricle contralaterally
  - ACA may also be compressed



Types of Brain Herniation

Transtentorial herniation:

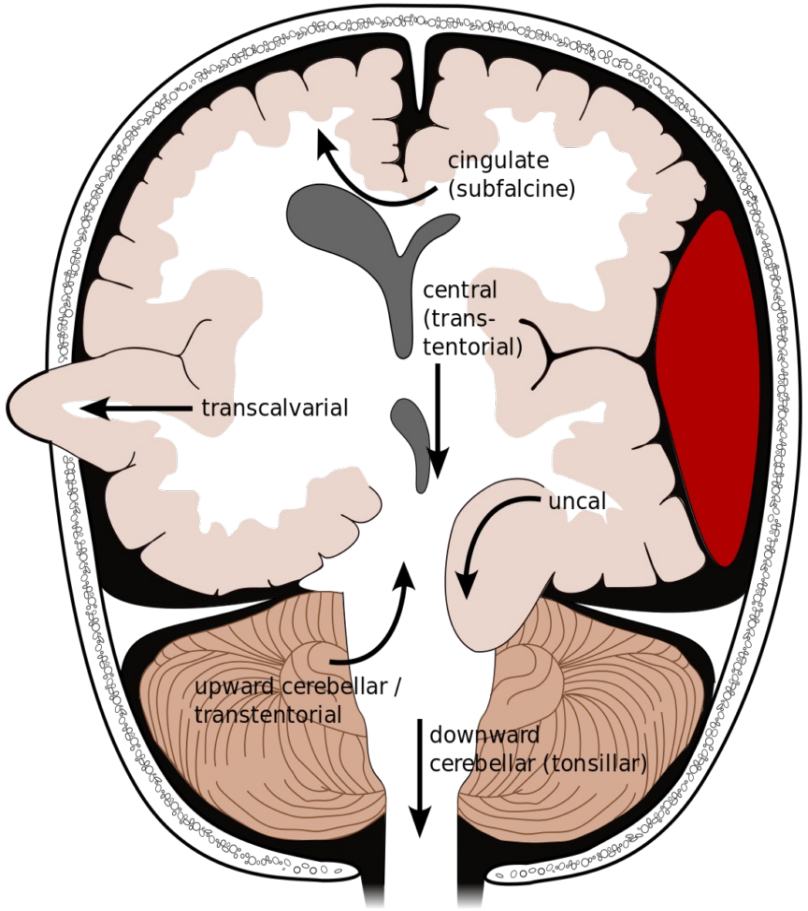
- descending herniation with the **uncus** and hippocampus pushed under the edge of the incisura (dorsum sella -> vein of Galen / straight sinus).
- RAS -> LOC
- Oculomotor nucleus -> ipsilateral dilated fixed pupil (CN III palsy)
- CST -> CL hemiparesis
- **Kernohan's notch**: compression of *contralateral CST* against the edge of tent→ ipsilateral hemiparesis (25%)
- obliteration of the suprasellar cistern
- AChA – BG stroke
- **PCA stroke**
- **Duret hemorrhage:** pontine stroke secondary to perforators
- **Basilar artery:** median perforating and circumferential arteries (no collaterals), Pcom, P2 (occipital) strokes



Types of Brain Herniation

Upward herniation:

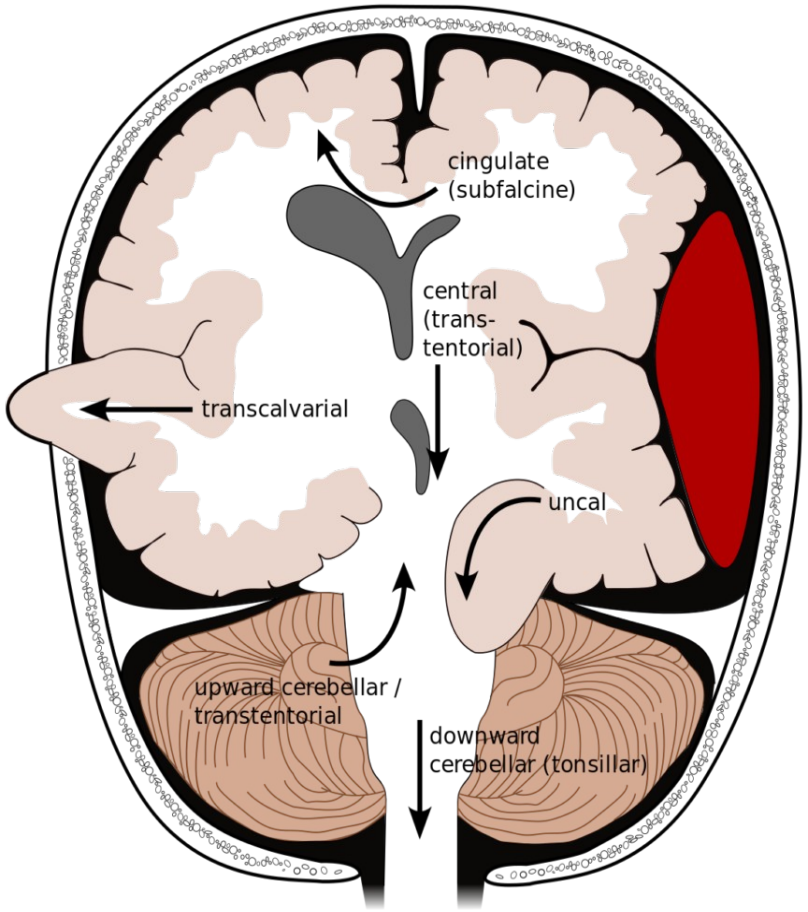
- From cerebellar vermis ascending -> effacement of the superior vermian cistern, quadrigeminal cistern, and 4th ventricle
- Unopposed PNS from midbrain, no SNS in pons -> pontine pupils
- Quad plate compressed -> no upgaze



Types of Brain Herniation

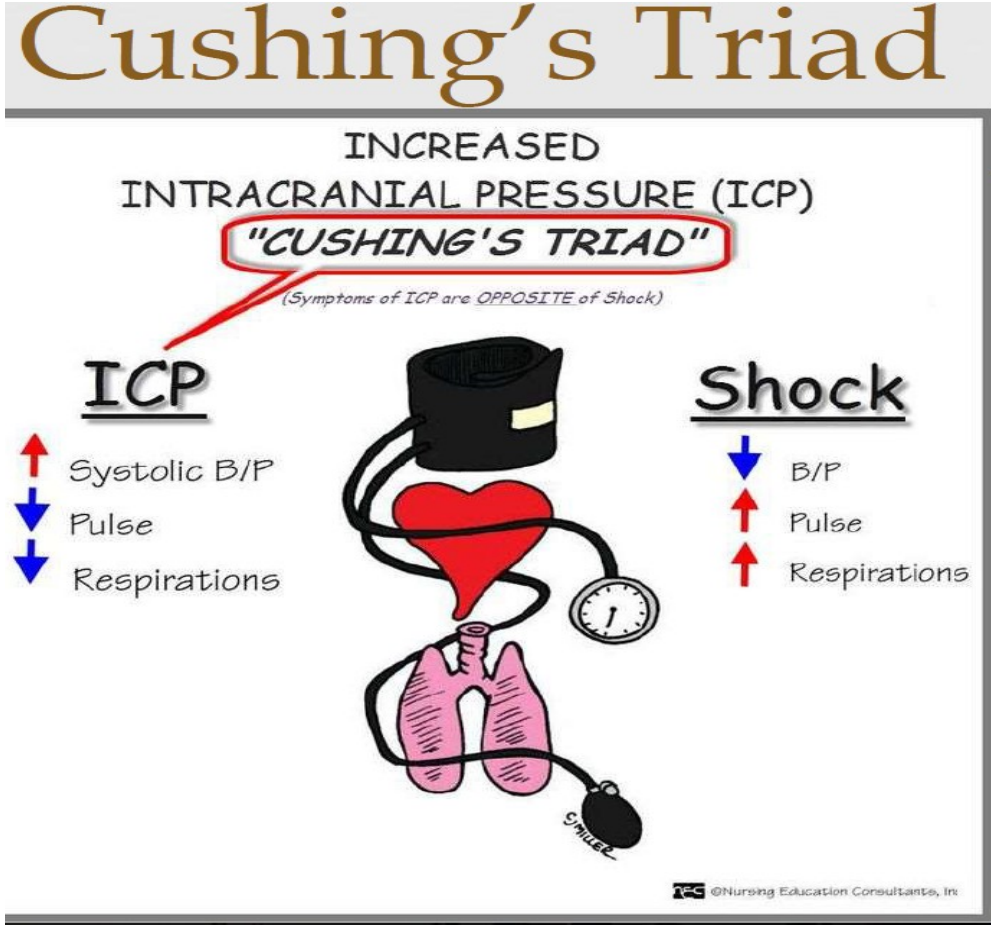
Tonsilar herniation:

- herniation of the cerebellar tonsils into the foramen magnum and compression of the medulla.
- an abnormal neck posture and a head tilt in slowly progressive herniation.
- Neck stiffness results from irritation of the dura around the foramen magnum.
- Compression of the medulla may cause rapid respiratory failure (Cheyne–Stokes breathing).
- These may occur without significant impairment of conscious state.
- The pressure from the herniated tonsils may cause abrupt limb paresis and sensory disturbance.



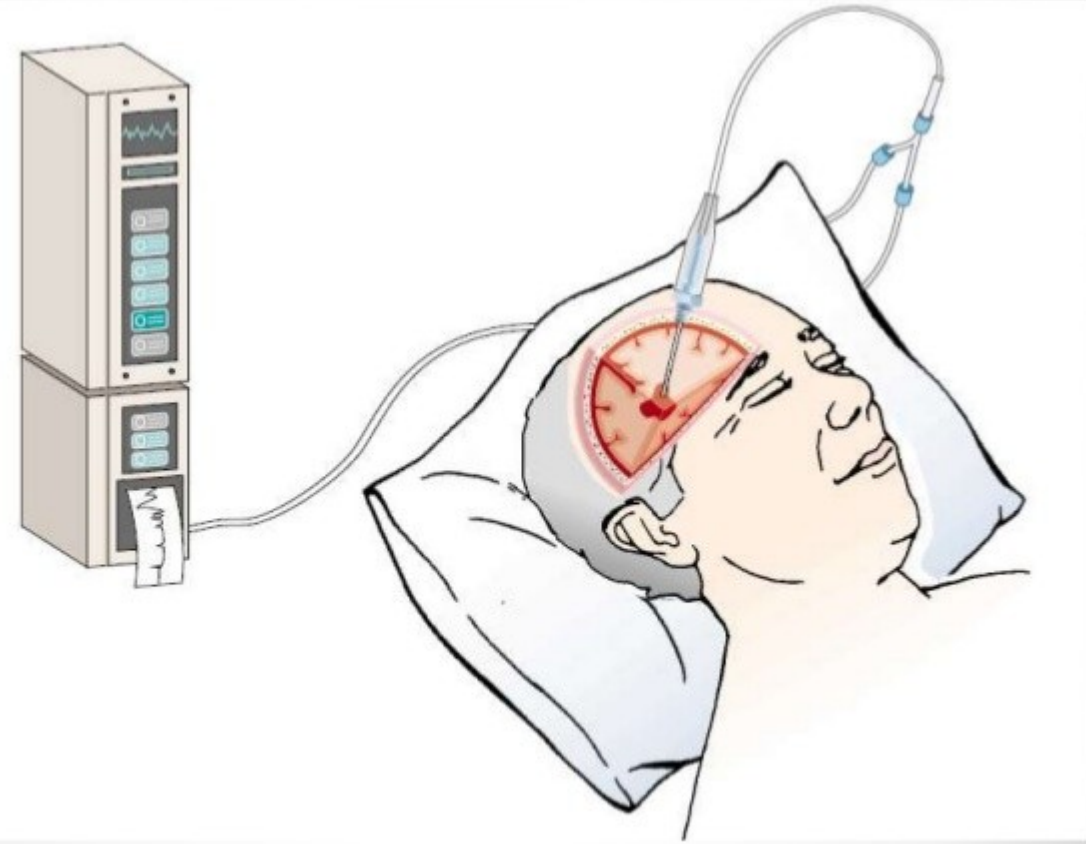
Clinical manifestation of increased ICP

- Headache.
- Nausea and vomiting.
- Drowsiness.
- Papilledema, 6th cranial nerve palsy or irregular pupils.
- Cushing triad hypertension, bradycardia and respiratory irregularity.
- Manifestation of herniation.



ICP Monitoring

- ICP should be monitored in patient with GCS 8 or less than 8 and in patient with abnormal CT b
- Methods:
  - Epidural
  - Subdural
  - Subarachnoid
  - Intraparenchymal
  - Interventricular



Management of increased ICP

Goals:

- Identify and treat the under lying cause of increased ICP.
- Maintain adequate perfusion and oxygenation of the brain.

Management of increased ICP

❑ *Measures to decrease ICP*

- Mannitol Infusion:

  it works by 2 mechanisms: osmotic diuretics

  plasma expanders

  it has immediate plasma expanding effect that reduce the haematocrit and blood viscosity thereby increasing CBF and cerebral oxygenation.

  it creates osmotic gradient that move fluid from brain tissue to plasma

Management of increased ICP

Measures to decrease ICP

- CSF withdrawal:

  continuous CSF drainage from ventricle as it’s formed within minutes.

- Sedatives:

  failed previous measures under careful control

  Propofol

  Etomidate

Management of increased ICP

❑ *Measures to decrease ICP*

- ➢ Controlled hyperventilation:

  it will decrease the CO2 level which will improve the condition within limits

- ➢ Decompressive craniotomy.
- ➢ Hypothermia: to less than 35degree.
- ➢ Steroids: stabilize all membranes.

  decrease oedema around tumours.

  no benefit in head injury.


Thank
you!!